Sept. 22, 1953 L. J. STERN 2,652,683

MASTER CLOCK SYSTEM

Filed Nov. 15, 1948 4 Sheets-Sheet 1

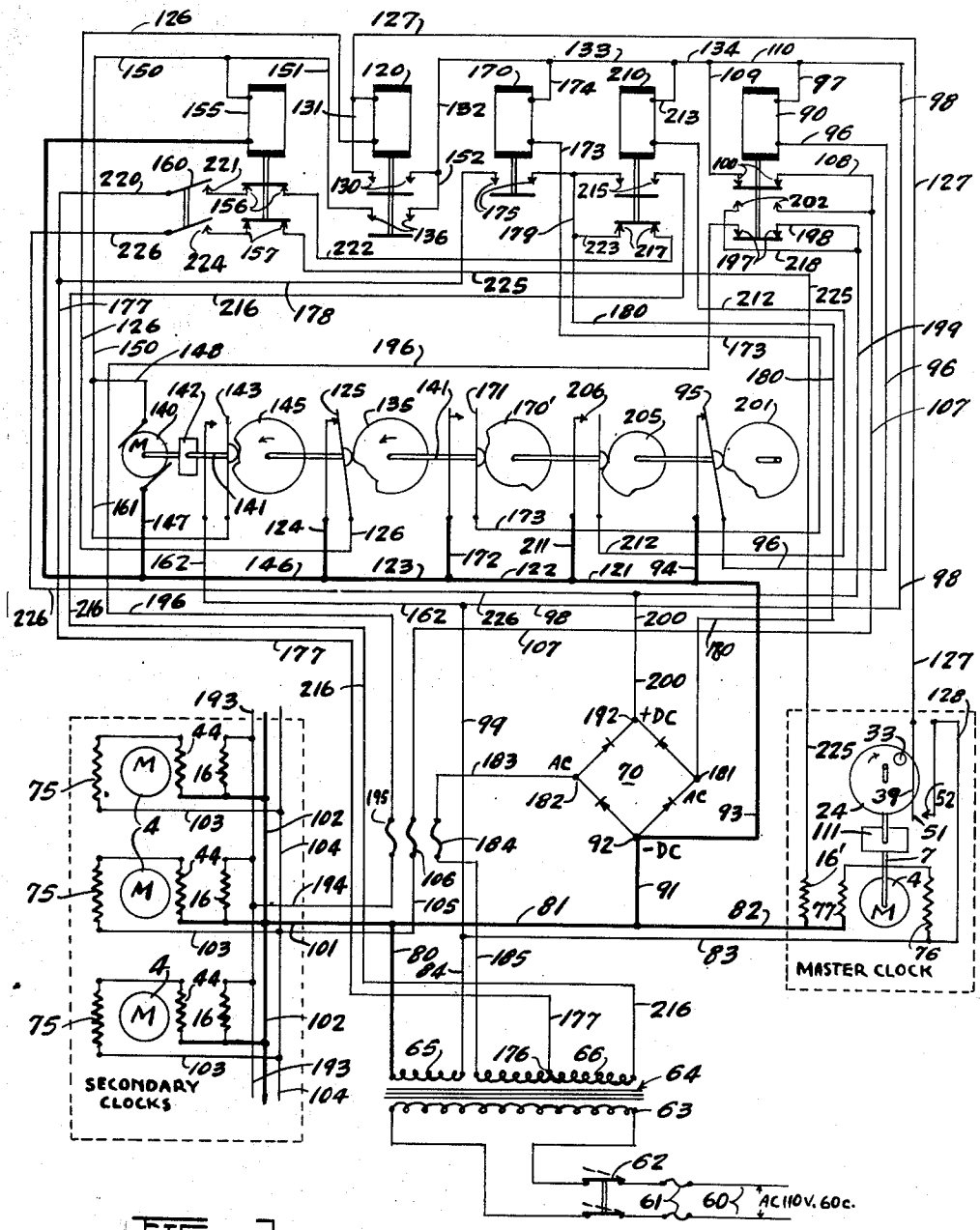


FIG - 1 -

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MASTER CLOCK SYSTEM

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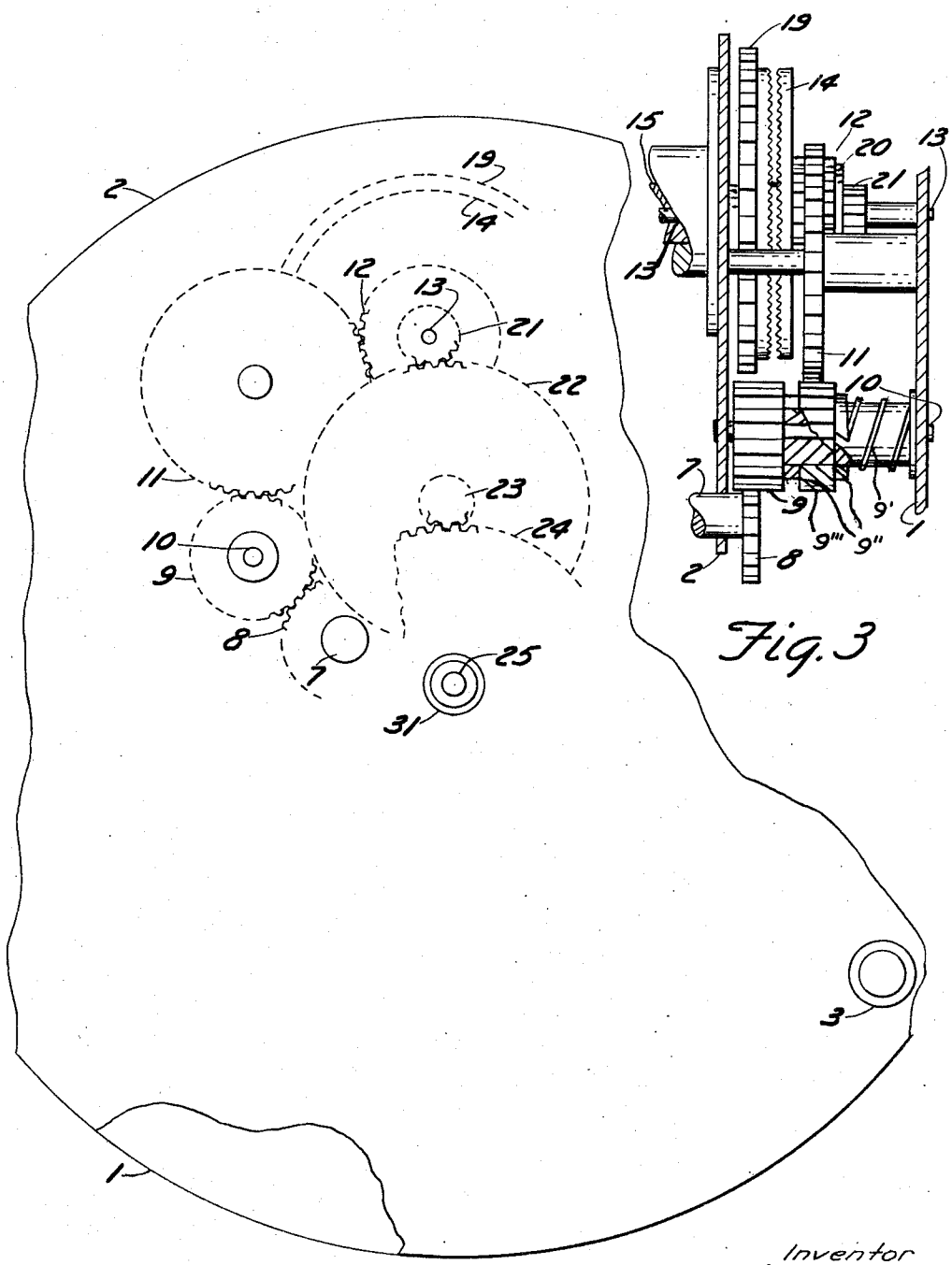


Fig. 2

Fig. 3

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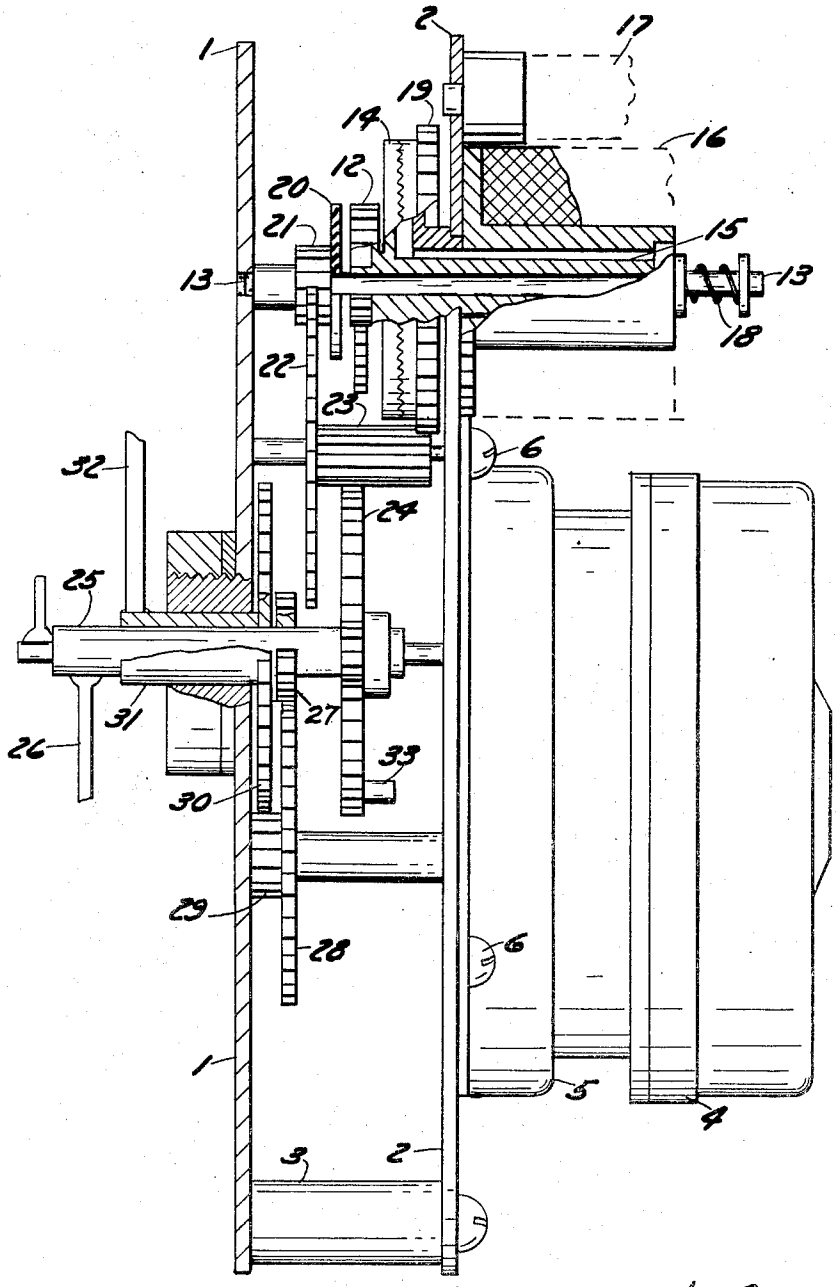


Fig. 4

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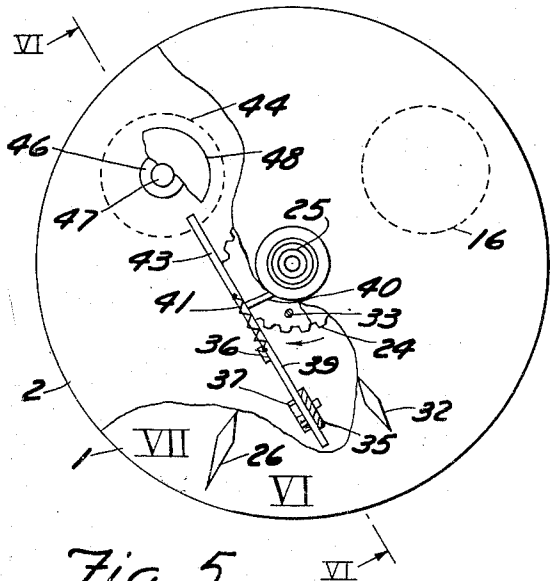


Fig. 5

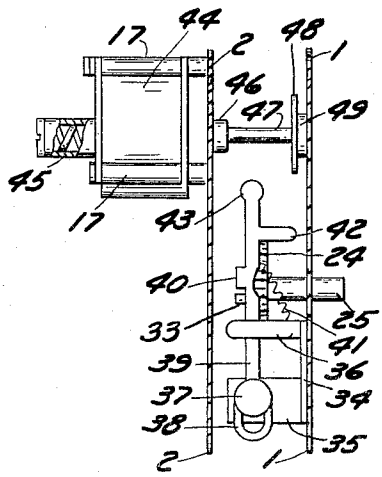
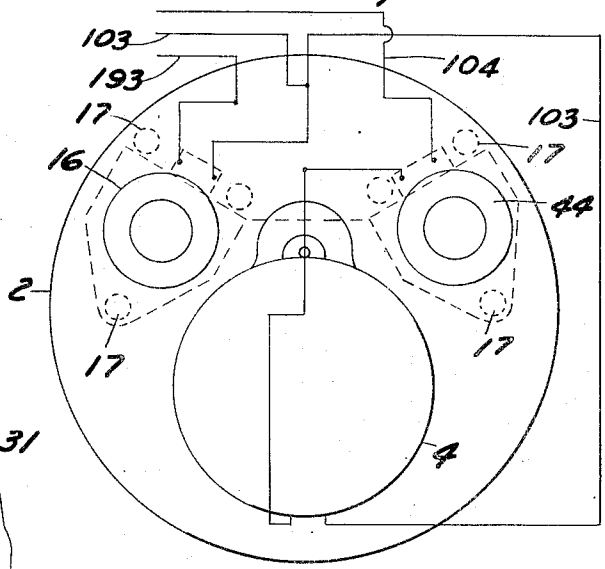


Fig. 6

Fig. 7



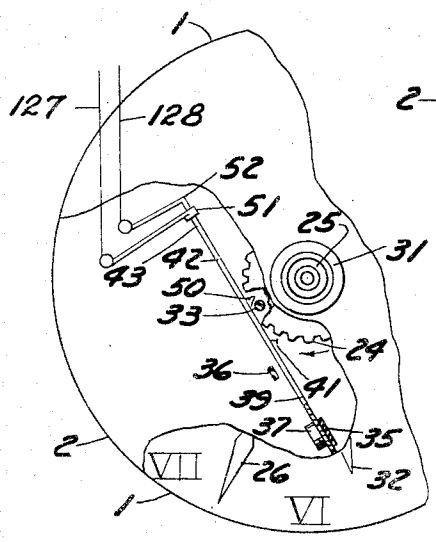


Fig. 8

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2,652,683

UNITED STATES PATENT OFFICE

2,652,683

MASTER CLOCK SYSTEM

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Application November 15, 1948, Serial No. 60,135

8 Claims. (Cl. 58—35)

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This invenion relates to master clock systems. More particularly, it deals with a system of a plurality of independent electric clocks which are periodically and automatically corrected or reset at regular intervals by a master clock, such as in a system of clocks for different rooms in a school or a hospital building.

This invention is an improvement of my copending application Serial No. 456,718 filed August 29, 1942, now U. S. Patent 2,498,462 issued February 21, 1950, including modifications for practically adapting the system of this patent for operating a large number of clocks, and modifications in the construction of the secondary clocks subservient to the master clock.

It is an object of this invention to produce a simple, efficient, effective and economic master clock system.

Another object is to produce such a system for automatically resetting a large number of separately driven electric clocks at regular intervals by one master electric clock.

Another object is to improve the driving and clutch mechanisms of the secondary clocks to prevent the motors from stalling and/or winding up the torsion in the gears of the clocks when they are stopped for resetting by the master clock during the correction interval.

Another object is to provide manual means for resetting simultaneously the master clock and all of the separately driven secondary clocks independently of their automatic correction and reset controlled by the master clock.

Another object is to improve the system of the prior U. S. Patent No. 2,498,462.

Generally speaking, the system of this invention comprises a master electric clock and a plurality of separately driven secondary electric clocks, all of which are driven from a common synchronous alternating current source. The automatic control of the correction of these clocks is provided through two direct current sources of different voltage, one of which voltage sources is controlled to speed-up the clocks to a pre-set stop point and the other of which is to release the stop after all of the clocks have reached this point. All three of these currents are conducted to the secondary clocks from the control means over only three conductors, one of which is common for the return of all of the currents and the other two of which are for the sending of the two different direct current voltages, one of which two alternates between one direct voltage and the alternating current source. Thus, the voltage which is employed for releasing the stops may be transmitted over the same circuit as the

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regular alternating current for running the secondary clock motors, but since all of the secondary clocks are advanced to await the proper pre-set release point, the interruption of the alternating current does not cause a delay.

The automatic control for resetting the clocks may be provided at regular intervals, such as once each hour, and this interval may be determined by a contact provided in the master clock circuit, which starts the control means. This control means comprises a series of motor actuated cams and corresponding control relays that control the current to operate the speed-up and release and regulate alternating current supplied to the secondary clocks of the system. This control interval preferably has a short duration, such as about one minute, and for example may occur during the 33rd or 34th minute after each hour.

The mechanisms of the clocks of this system are driven through a plurality of friction clutches, one or the other of which is always engaged either through direct drive or speed-up of the clocks, so that in the event one of the clocks reaches its stop before another, the motor in that clock will not be stalled. Also each clock has an electromagnet actuated by one of the direct current voltages for operating the speed-up device, and each of the secondary clocks has a second electromagnet actuated by the other direct current voltage for operating the release device, which second electromagnet may be connected in series with the induction motor for driving the secondary clocks so that said other direct current voltage and the alternating driving current may be alternately conducted through the same circuit in the secondary clocks, thus reducing the number of conductors required for their correction control.

There may be provided a manually controlled circuit for resetting or correcting all of the clocks, which circuit is independent of the automatic control means, but employs the same conductors between the secondary clocks and the current sources.

The above mentioned and other features and objects of this invention and the manner of attaining them are given more specific disclosure in the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a schematic wiring diagram of the system of this invention, disclosing a master clock and a plurality of secondary clocks with their three current supplies, and their automatic and manual correcting and resetting control means;

Fig. 2 is a fragmentary view of the face of one of the master or secondary clock mechanisms showing in dotted lines some of the drive gearing therefor;

Fig. 3 is a partial view taken from the left of Fig. 2 showing part of the gear train from the driving motor shaft, and the clutches employed in this gear train for speeding-up the clock mechanism during reset intervals;

Fig. 4 is a partial sectional side view taken from the right of Fig. 2, showing the gearing between the speed-up clutch mechanism and the time indicators or hands of the clock;

Fig. 5 is a reduced face view of a secondary clock with parts of the face broken away, showing the clock stop lever and control device;

Fig. 6 is a section taken along line VI—VI of Fig. 5 of the stop lever and release magnet therefor;

Fig. 7 is a view of the back of a secondary clock showing the location of the electromagnetic coils and their electrical connections in relation to the electric clock motor;

Fig. 8 is a fragmentary front view of the master clock, with a portion of the face broken away, to show the mechanism for governing the automatic reset or correction interval for the secondary clocks of the system.

Before describing the electrical control circuit of Fig. 1 the mechanism of the mechanical drive of the electric clocks and their speed-up, stop and release devices will be described so that the operation of the circuit of Fig. 1 may be better understood.

I. CLOCK MECHANISMS

1. *The speed-up device*

Referring first to Figs. 2, 3 and 4, the gears for operating the clocks may be mounted between a pair of parallel plates or disks 1 and 2 which are held together by a plurality of posts 3. On the outside of back plates 2, a synchronous motor unit 4 (see Fig. 4) which may have a built-in gear reduction housing 5, may be mounted by means of suitable screws 6. Projecting through the plate 2 from the units 4 and 5 may be a motor drive shaft 7 (see Figs. 2 and 3) which may be driven at a reduced rate by the electric synchronous clock motor 4. Fixed on this shaft 7 may be a pinion 8 in mesh with a gear 9 which is loosely mounted on a shaft 10, between the plates 1 and 2 parallel with the shaft 7. Also loosely mounted on the shaft 10 is a second gear 9''' which is urged into contact with the gear 9 by means of a spring 9' against a pair of friction disks 9'' on each side of said gear 9''', so that there is a slip friction engagement between the motor and the remaining of the gear mechanism. In mesh with the friction driven pinion 9''' is a larger gear 11 which also meshes with a loose pinion 12 mounted on a stem or shaft 13 parallel to the shafts 7 and 10.

Connected to one side of the pinion 12 (Fig. 4) may be a larger diameter crown-toothed clutch disk 14 which together with the pinion 12 is axially movable along the shaft 13. Also connected with the pinion 12 and clutch disk 14 is a tubular extension 15 connected to an axially movable core of an electromagnet. This tube 15 extends through an aperture in the plate 2 and is surrounded by the coil 16 of the electromagnet, mounted on the plate 2 by means of posts 17. A compression helical spring 18 on the pin or loose shaft 13 normally urges the tube 15 together with its pinion 12 and clutch 14 towards the face plate 1 in the position shown in Fig. 3, which is out of engagement with the complementary crown-toothed clutch face gear 19 which rotates freely on a hollow stud around tube 15. Spring 18 urges the tube 15, clutch plate 14 and pinion 12, to engage the pinion 12 with a fiber clutch disk 20, which may be fixed to another pinion gear 21 loosely mounted on the stem 13, and in mesh with a larger gear 22 (see Fig. 4). The gear 22 has fixed thereto a long pinion 23 in mesh with the normally loose gear 19, as well as in mesh with the minute hand gear 24, which is connected with the shaft or sleeve 25 through a bearing in the face plate 1 to the minute hand 26 of the clock. Thus, in the normal operation, the minute hand is driven back through its gear 24, long pinion 23, gear 22, pinion 21, clutch 20, pinion 12, gears 11 and 9''', clutches 9'' and gears 9 and 8 to the motor drive shaft 7. The large complementary gear portion 19 of the crown-toothed clutch, which also is driven by the pinion 23, merely idles on the core 15 since it is out of mesh with the crown-toothed clutch plate 14, as shown in Fig. 3.

For driving the hour hand of the clock there may be provided a second pinion 27 on the hollow shaft 25 which meshes with a gear 28 affixed on a coaxial adjacent pinion gear 29 that drives the larger gear 30 on a cylindrical shaft 31 surrounding the shaft 25, to which is attached the hour hand 32.

When speed-up is required, the coil 16 may be energized with a low voltage direct current as will be described later, and the core 15 with gear 12 and clutch plate 14 is pulled towards the back plate 2, into the position shown in Fig. 4, so that the crown-toothed clutch members 14 and 19 are in mesh, and the friction clutch 20 is released from the pinion 21. The drive is now through the large gear 19 to the pinion 24, and pinion gear 21 is now an idler. The difference in ratio between the gears 21 and 22 is now reversed through gears 19 and 23, and the hands of the mechanism are speeded up materially, say for example about 60 times, as the clock motor continues to operate. However, as soon as the direct current is cut-off through the coil 16, the spring 18 disengages the clutch 14 and reengages the clutch 20, so that normal operation will resume as previously described.

The above described mechanism of Figs. 2, 3 and 4 may be the same, and preferably is the same, for all of the secondary clocks as well as the master clock, although the clutch 9'' is not required in the master clock.

2. *Secondary clock stop and release devices*

Referring now to Figs. 4, 5, 6 and 7, there is shown on the minute hand gear 24 of each clock, an axially parallel extending peg 33, projecting towards the rear face plate 2. In Figs. 5 and 6 there is shown a bracket base 34 having upstanding lever guides 35 and 36, in the former of which may be provided a headed pin or a pivot 37 which extends through a slot 38 in one end of a slidable bar or stop lever 39, which lever 39 may both slide and pivot on the pin 37. Extending perpendicularly from one side of the lever 39 may be an arm 40 which projects into the normal path of the rotating peg 33 (see Fig. 5), so that as the minute hand wheel 34 turns in the direction of the arrow, the peg 33 will hit against the arm 40, and pull or slide the lever 39 longitudinally in its pivot 37 the length of the slot 38, against the action of a

helical tension spring 41 connected between the lever 39 and the fixed lever guide 36 (see Fig. 6). Near the other end of the lever 39, there may be provided a leg 42 projecting toward the plate 1, which limits the rotation of the lever 39 in one direction around the pivot 37 by contacting against the inner surface of plate 1, thus maintaining the outer projecting end 43 of the lever 39 spaced from the plate 1.

Adjacent the outer end 43 of the lever 39, there may be mounted on the back plate 2, a second additional electromagnetic coil 44, provided with a compression helical spring 45 axial with a magnetic core 46 of the electromagnet which normally projects a stem 47 of the core 46 outside of the coil 44 into the space between the plates 1 and 2, as shown in Fig. 6. On the outer end of this stem 47, may be mounted a disk or plate 48, which may be spaced from the inside of the front plate 1 by means of a cushion 49. The leg 42 on the lever 39 thus spaces the end 43 sufficiently away from the inner face of the plate 1, so that when the peg 33 on the wheel 24 pushes the lever longitudinally away from its pivot 37, the outer end 43 of the lever 39 will be projected into the axial path of the motion of the plate 48 connected to the electromagnetic core 46.

Thus, during automatic correction intervals, after the secondary clocks are speeded-up and their pegs 33 have pushed their levers 39 to their stop positions (that is, pushed their ends 43 into the axial paths of the plates 48 and maintained them there by the drive from motors 4 through the slippage of clutches 9''), the stop release electromagnetic coils 44 are simultaneously energized to move their plates 48 to contact ends 43 and rock the levers 39 around their pivots 37 against the action of springs 41, so that the projecting arms 40 will be moved beyond or over the heads of the pegs 33 on the gears 24 releasing said gears 24. The springs 41 will then retract the levers 39 again into the position shown in Fig. 6, but the pegs 33 will now be on the opposite sides of the stop arms 40, and the motors of the secondary clocks may continue to operate their clock hands 26 and 32 normally without obstruction until gears 24 with pegs 33 again contact the stop arms 40 upon the next revolution.

3. *The master clock control switch*

Referring now to Fig. 8, there is also employed in the master clock a similar lever mechanism 39 as described above and mounted in the same way, but instead of this lever carrying a definite stop arm 40 it is provided with a cam faced projection 50 so that the peg 33 on the minute hand wheel 24 will push the lever longitudinally so as to close a pair of contacts 51 and 52, one of which may be mounted on the lever 39. The time for this closure may be very short since the cammed projection 50 permits the peg 33 to move on without delay or retardation of the master clock, and to slide off the projection 50, opening again the contacts 51 and 52 by retraction of the lever 39 under the action of its spring 41. It is these contacts 51 and 52 which start the automatic correction circuit for automatically speeding-up and releasing all the secondary clocks at exactly the same instant each hour according to the circuits shown in Fig. 1. This control circuit is made responsive even to the slightest closing of the contacts 51 and 52, and maintains itself operated during the entire correction interval, which, say for example, may be about one minute in duration as mentioned above. Since the lever 39 in the master clock engages the pin 33 only through the cam projection 50, it is not necessary that it both slides and pivots, in that one or the other motion could be sufficient to close the contacts 51 and 52.

Thus there are three conditions which may exist in the system depending upon the relationship of the timing of at least one secondary clock to the master clock:

(1) That a secondary clock is exactly in time with the master clock under which circumstances the secondary clock would be speeded-up only for the time indication equivalent to the correction interval, stopped by arm 40, and released at the end of the correction interval;

(2) That a secondary clock was too fast and would be stopped by the lever arm 40 until it could be released at the exact moment by the completion of the correction interval set up by the master clock; and

(3) That a secondary clock was too slow and would be speeded-up during the correction interval for a time indication more than said interval and then stopped for release exactly at the proper instant and in correct time register with the master clock.

II. THE CONTROL CIRCUIT

1. *Normal operation*

Referring to Fig. 1 the power supply may be normal 110 volts 60 cycle alternating current which may be introduced into the circuit through the conductors 60 and circuit breakers or fuses 61 and a manual cut-off switch 62, located at the bottom central portion of the circuit in Fig. 1. Let us assume that the manual switch 62 is closed and all of the clocks, both master and secondary clocks, are in their normal operation.

Current is supplied to the primary winding 63 of a transformer 64 which may be provided with two separate secondary windings, one secondary winding 65 for the alternating current supply for the synchronous induction motors of the clocks, and the other secondary winding 66 which may be provided with a central tap which is connected to a full wave rectifier 70 from which two different voltages of direct current may be withdrawn depending upon which pair of taps to the secondary coil 66 are connected across the alternating current input terminals of the rectifier 70.

Since one of the features of this invention is completely to control the secondary clocks over three conductors or wires, one of the electromagnetic coils provided in the secondary clocks, namely the release coils 44, are connected in series with the field windings 75 of the corresponding synchronous motors 4, so that in order to prevent too much energy being used up in the coils 44 the secondary winding 65 of the transformer may slightly step-up the alternating current voltage, say from for example about 110 to 135 volts, so that these clocks will not be unnecessarily slowed down by the impedance of the coils 44 in series with the field windings 75. Similarly, in the master clock motor, which is operated from the same secondary windings 65, may have its field winding 76 connected in series with an additional balancing coil 77, which corresponds in impedance to the coils 44, but does not operate an electromagnet or a release coil, in that such is not provided or necessary in the master clock circuit.

The conductors which are shown in heavy lines in Fig. 1 are common for all three of the currents employed in this control system.

The master clock motor 4 is energized by secondary winding 65 through heavy conductors 80,

81 and 82 through balancing coil 77, field coil 76 and return conductors 83 and 84 to the secondary winding 65.

The secondary clock motors, however, are energized through a contact of an alternating current relay 90 in the upper right hand corner of the circuit which is normally energized as long as the switch 62 is closed and the automatic correction circuit is not in operation. This relay 90 is energized from the secondary winding 65 through conductors 80, 81, 91 to the negative terminal 92 of the rectifier 70, and then conductors 93 and 94 to normally closed cam operated contacts 95, conductor 96 through the coil of relay 90 and then back to the secondary winding 65 through conductors 97, 98, 99 and 84.

The motors 4 of the secondary clocks then have their field windings 75 energized also from the secondary winding 65 of transformer 64 through now closed contacts 100 of the relay 90 according to the following circuit: secondary winding 65, conductors 80 and 101, common conductor 102 for all of the secondary clocks, coils 44, windings 75, and back through the conductors 103 to common conductor 104, and thence conductor 105 which may pass through a fuse 106, conductors 107 and 108, closed contacts 100 of relay 90, conductors 109, 110, 98, 99 and 84 to the other terminal of the secondary winding 65.

The above traced circuits are those energized for the normal operation of all of the clocks outside of the correction intervals, with all of the secondary clocks separately operated by individual motors over a common alternating current supply circuit which also maintains the relay 90 energized.

2. *Initiation of the correction control circuit*

As soon as the master clock has rotated its minute gear or wheel 24 through the normal clock mechanism, indicated in Fig. 1 as box 111 and containing the gear trains and clutches shown in Figs. 2, 3 and 4, so that the peg 33 will operate the lever 39 to close contacts 51 and 52, another alternating current circuit is closed to energize alternating current relay 120, which is the second relay from the left in the top row of alternating current relays shown in Fig. 1. The circuit for the energization of this relay 120 is also taken from the alternating current supply of secondary winding 65 of transformer 64, which may be traced through conductors 80, 81, 91, 93, 121, 122, 123, 124, normally closed cam operated contacts 125, conductor 126 to the coil of relay 120, and thence through conductor 127 to the master clock, now closed contacts 51 and 52, conductor 128, from the master clock through conductors 83 and 84 to the other terminal of the secondary winding 65.

The energization of relay 120 closes its self-holding contacts 130 which bypass the contacts 51 and 52 in the master clock to maintain the relay 120 energized through the following circuit: secondary winding 65, conductors 80, 81, 91, 93, 121, 122, 123, 124, cam operated contacts 125, conductor 126, relay 120, conductor 131, now closed self-holding contacts 130, conductors 132, 133, 134, 110, 98, 99 and 84 to the other terminal secondary winding 65. Thus, if the contacts 51 and 52 are only instantaneously closed the operation of relay 120 will be insured for the proper time in the correction cycle interval when cam 135 rotates to open its contacts 125 breaking the above circuit to relay 120.

Relay 120 also closes contacts 136 which energizes the cam operating motor 140 which may rotate cam shaft 141 through a reduction gear or transmission mechanism 142, so that during the correction interval, shaft 141 and the cams thereon make one complete rotation under the control of cam operated contacts 143, operated by the first cam 145 mounted on shaft 141. The circuit for the energization of the cam alternating current motor 140, which also may be an induction motor as motors 4 or any other type of motor without departing from the scope of this invention, is energized from the secondary winding 65 of the transformer 64 through conductors 80, 81, 91, 93, 121, 122, 123, 146, 147, cam motor 140, conductors 148, 150, 151, now closed contacts 136, conductors 152, 132, 133, 134, 110, 98, 99 and 84 to the other terminal of secondary winding 65.

The closure of contacts 135 of relay 120 also energizes the relay 155 opening its contacts 156 and 157 to break the circuit for the manual advancing of all of the clock motors through the closure of manual switch 160 as will be described later in section 5 of this chapter II, so that if switch 160 is closed, its circuit will be opened so that the automatic correction under the control of the master clock through contacts 51 and 52 will not be effected by the manual operation of the switch 160.

The first contacts which are closed by the rotation of the cam shaft 141 after the energization of the cam motor 140 are contacts 143, which bypass the contacts 136 of the relay 120 and hold the motor 140 energized until the cam follower on the contact 143 rides off the surface of the cam 145 again into the position shown in Fig. 1 after one revolution of cam shaft 141. This holding circuit for the motor 140 may then be traced from the secondary winding 65 through conductors 80, 81, 91, 93, 121, 122, 123, 146, 147, cam motor 140, conductors 148 and 161, now closed cam operated contact 143, conductors 162, 99, and 84 to the other terminal of the secondary winding 65.

3. *Speed-up secondary clocks*

Next relay to be operated is relay 170 which is energized by cam 170' closing of cam operated contacts 171 shortly after the closure of the contacts 143. The circuit for the energization of this relay is thus also from the secondary winding 65 through conductors 80, 81, 91, 93, 121, 122, 172, just closed cam operated contacts 171, conductor 173, coil of relay 170, conductors 174, 133, 134, 110, 98, 99 and 84 to the other terminal of the secondary winding 65.

The energization of relay 170 closes its contacts 175 to apply a low alternating current voltage from the other secondary winding 66 taken from the middle tap 176 of that winding, to the alternating current terminals of the rectifier 70 which thus produces the first and lower direct current voltage. This circuit through the rectifier 70 is from the middle tap 176 through conductors 177, 178, now closed contacts 175, conductors 179 and 180 to one alternating current terminal 181 of rectifier 70, through the rectifier to the other alternating current terminal 182 and then conductor 183 which also may pass through a suitable fuse 184, and then conductor 185 to one end terminal of the secondary winding 66.

Now since the lower alternating current voltage is applied across terminals 181 and 182 of the rectifier 70, the lower of the two direct current voltages are applied across the two other poles,

negative pole 92, positive pole 192, of the rectifier 70 completing a circuit energizing the speed-up coils 16 in all of the secondary clocks. The circuit from —D. C. pole 92 through these coils 16 to +D. C. pole 192 may be traced as follows: conductors 91, 81, 101, common conductor 102, through each of the electromagnetic coils 16, and back through common conductor 193, conductor 194 which may pass through a fuse 195, conductor 196, through the normally and now closed contact 197 of relay 90, conductors 198, 199 and 200 to the +D. C. pole 192. The simultaneous energization of all of the electromagnetic coils 16 in each of the secondary clocks of this system causes the retraction of their cores 15 (see Fig. 4) to engage the two crown-toothed clutch parts 14 and 19 so that the driving motors 4 still operating for each of the secondary clocks will speed-up the movement of the minute hands of each of the clocks for a period of, for example about 40 seconds of the one minute automatic correction interval, which is more than sufficient for the pegs 33 on the wheels 24 to engage the stops 40 and push their levers 39 to their extreme end positions with their outer ends 43 projecting in the paths of the release magnet disks 48 (see Fig. 6). As soon as the levers 39 have been slid as far as possible to the ends of slots 38, their wheels 24 and minute and hour hands 28 and 32 will stop, and the clutches 9'' will slip until the stop 40 are removed from the pegs 33 by the energization of the release magnets 44 described in the next chapter, or their motors 4 are deenergized.

After the cam shaft 141 has rotated for about ⅔ of its complete revolution or namely for about 40 seconds, cam 170' opens the contact 171 again breaking the circuit through relay 170 so that this relay becomes deenergized and breaks the lower potential alternating current circuit applied across contacts 181 and 182 of the rectifier 70, which therefore cuts off the energy for the lower D. C. circuit deenergizing the electromagnetic coils 16 in each of the secondary clocks, so that the clock motors are now operated again at a regular speed although their hands are still stopped by levers 39.

4. *Stop release of secondary clocks*

Shortly after the opening of the contact 171 by cam 170', another cam 201 opens the contacts 95 breaking the circuit to the relay 90 which then deenergizes, opening the circuit between contacts 100 and 197 and closing contacts 202. The opening of contacts 100 breaks the alternating current circuit to the motors 4 of each of the secondary clocks, so that these motors are now stopped during the remaining few seconds (about 4 seconds which is sufficient for motors to come to rest) of the correction interval, so that the higher direct current voltage may be applied over the same circuit to energize the stop release coils 44 connected in series with the field windings 75 of the synchronous induction motors 4. The opening of contacts 197 directly breaks the lower D. C. circuit through coils 16 in the secondary clocks, so that the motors 4 remain geared again at their regular speeds by the engagement of gear 12 (see Fig. 3) with friction disk 20 to pinion 21 under the action of spring 18. The making of the contacts 202 connects the higher D. C. circuit across terminals 92 and 192 of rectifier 70 with the stop release magnet coils 44 in series with the field coils 75 in each of the secondary clocks preparatory to the application of a higher alternating current across the A. C. terminals 181 and 182 of the rectifier 70.

Immediately thereafter, further rotation of the cam shaft 141, causes cam 205 to close its cam operated contacts 206 to energize the higher voltage alternating current circuit, by first energization of relay 210 through the circuit of the secondary winding 65, conductors 80, 81, 91, 93, 121, 211, just closed cam operated contact 206, conductor 212 to the coil of relay 210, and thence through conductors 213, 134, 110, 98, 99 and 84 to the other terminal of the secondary winding 65. The energization of relay 210 closes contacts 215 which closes the higher voltage A. C. circuit through the other secondary winding 66 of the transformer 64 as follows: one end of the coil 66 through conductor 216 now closed contacts 215 of relay 210, conductors 179, 180, to the A. C. terminal 181 of rectifier 70, through the rectifier 70 and then from A. C. terminal 182 through conductor 183, fuse 184, and conductor 185 to the other end of the secondary winding 66.

The opening of contacts 217 by the energization of relay 210 breaks the circuit again through the manual switch 160 mentioned above, so that in the next sequence when relay 120 and 155 will be deenergized before the completion of the correction interval, operation of the switch 160 will have no effect on the automatic correction cycle.

The application of the higher A. C. voltage across terminals 181 and 182 of rectifier 70 now supplies a higher D. C. voltage in the circuit from —D. C. pole 92, through conductors 91, 81, 101, common conductor 102, stop release coils 44 and field windings 75 and conductor 103 of each of the secondary clocks, and thence through common conductor 104, conductor 105, fuse 106, and conductor 107, already closed contacts 202 of deenergized relay 90, conductors 218, 199 and 200 to the +D. C. pole 192 of the rectifier 70. With this higher D. C. voltage now applied in series through winding 75, electromagnetic coils 44 are sufficiently and simultaneously energized to retract their cores 46 (see Fig. 6) together with their extensions 47 so that the disks 48 will contact the ends 43 of the extended stop levers 39 to move the stop arms 40 over the ends of pegs 33 for the springs 41 to retract these levers 39 back into their normal positions shown in Fig. 6, with the pegs 33 released and ready to continue the operation of the clocks as soon as the motors 4 for the secondary clocks are again started.

The energization of release coils 44 continues until the cam 205 rotates to open contacts 206 again breaking the circuit to relay 210, which removes the higher A. C. voltage from A. C. terminals 181 and 182 of the rectifier 70, and correspondingly cuts-off the high D. C. voltage supply to the circuit through release coils 44 in each of the secondary clock circuits.

Right after and during the closure of the cam contacts 206, cam 135 opens its cam operated contact 125 which deenergizes the circuit to relay 120 causing this relay to release, which in turn breaks the circuit to relay 155 by the opening of contact 136, causing relay 155 to release so that relays 120 and 155 are again in the position shown in Fig. 1 preparatory to normal operation of the secondary clocks.

Then after the cam contacts 206 are opened and release coils 44 deenergized, the cam 201 closes again contacts 95 for energizing again the relay 90, which according to the above traced circuits in section 1 above of this chapter II, again starts the secondary motors 4 for all the

secondary clocks and the circuit is accordingly in normal operation again. Since the restarting of all the secondary clock motors is simultaneous and instantaneous, they are accordingly all in proper register with each other and the master clock.

Synchronized closely with the re-closure of the contacts 95 by the operation of cam 201, the first cam 145 opens the contacts 143 in the circuit to the cam motor 140, so that this cam motor now will stop in the position shown in Fig. 1, indicating the end of the correction interval and the starting position for the next automatic correction interval.

5. *Manual reset circuit*

If it is desired to correct the time of the master clock by advancing it, and simultaneously therewith advancing of all of the secondary clocks, so that all the clocks of the system will be in register with each other, the manual switch 160 near the upper left hand corner of the circuit of Fig. 1 may be closed to accomplish this result, at any time except during an automatic correction interval.

The closure of this double pole manual switch 160, completes the lower A. C. circuit to A. C. terminals 181 and 182 of the rectifier 70 from the center tap 176 of the other secondary winding 66 of transformer 64, through conductors 177, 220, contact 221 of switch 160, now and normally closed contacts 156 of deenergized relay 155, conductor 222, now and normally closed contacts 217 of deenergized relay 210, conductors 223, and 180, to terminal 181, through the rectifier 70, and thence from the other A. C. terminal 182 through conductor 183, fuse 184 and conductor 185 to an end terminal of said other secondary coil 66. The low A. C. voltage now applied to the rectifier 70 supplies a lower voltage D. C. circuit which may be traced through each of the speed-up coils 16 not only in the secondary clocks but also through speed-up coil 16' in the master clock, which corresponds physically with electromagnetic coils 16 previously described in Figs. 2, 3 and 4, as follows: from —D. C. pole 92 of rectifiers 70, through conductors 91, 81, 101, 102, coils 16 of each of the secondary clocks, conductors 193, 194, fuse 195, conductor 196, now closed contacts 197 of relay 90, conductors 198, 199 and 200 to the +D. C. pole 192; and simultaneously parallel to this circuit a similar D. C. circuit from —D. C. pole 92, through conductors 91, 82, speed-up coil 16' of the master clock, conductor 225, now closed contacts 157 of relay 155, contact 224 of switch 160, and then conductors 226 and 200 to the +D. C. pole 192 of the rectifier 70. Thus, as long as the manual switch 60 is maintained manually closed all of the clocks, both master and secondary, will be speeded up at a rate of about 60 times their normal speed until all the clocks are at the desired indicated time, at which time the switch 160 must be manually opened or released. It should be noted, however, that this speed of advance cannot be made for more than 59 minutes at a time, because as soon as the pegs 33 in each of the clocks, including the master clock, engage their corresponding stop arms 40 and cam arm 50, respectively, this manual advancing circuit will be automatically cut-out according to the operation described above in sections 2, 3 and 4 of this chapter II. Thus, for resetting the clock for each hour of delay, it will take 2 minutes of time for the closure for the manual switch 160, one minute for the 59 minutes advance at fast rate, and another minute for the 60th minute of each hour in which the automatic correction interval occurs, after which interval the clocks will again advance fast for the next 59 minutes if manual switch 160 is still closed, and so on until the manual switch 160 is opened.

Advantageous features of the present invention include separate relays for each of the cam operated switches, and these cam operated switches only operate their corresponding relays with the actual current for operating the motors and coils in the clocks of the system connected through the contacts of these relays, thus enabling much higher currents to be controlled than could be controlled through cam operated switches, such as currents for a system of a large number of secondary clocks. Another advantage is in the construction of the pivoted and slidable lever 39 and released mechanism for the stopping device in the secondary motors, which are definite and positive in their action. Still another advantage is that both of the electromagnetic coils in the secondary clocks, are connected in separate control circuits and not necessarily required to rely upon potential level selection for operation. All of the relays of the control circuit are alternating current relays and operated by the 110 v. or 135 v. alternating current supply, and all of the electromagnetic control coils 16, 16' and 44 are operated only by direct current. Another feature of the present invention is the employment of the additional friction clutch 9'' at the input driving connection to prevent both (1) the stalling of any of the motors when stopped at their output regardless of the speed of drive of the output, and to prevent (2) the winding up of the gears in the clocks between their inputs and outputs, such as by taking up the back lash in the gears and then placing torsion in the shafts between pairs of gears on the same shaft, by the continued torque from the motor when the clocks are stopped near their outputs while their motors are still energized, so that when the stops are released the hands at the outputs of the clocks will not jump ahead and give an incorrect time indication.

While there is described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of this invention.

What is claimed is:

1. In a system for synchronizing at predetermined intervals a secondary electric clock with a master clock said secondary clock having a time disclosing movement, said secondary clock being operated by an alternating current synchronous motor having a field winding, said system comprising: an alternating current source, two direct current sources of different voltage, and three conductors connecting said clocks and sources, one pair of said three conductors conducting selectively the alternating current from said source for said motors and one voltage of said direct currents, another pair of said three conductors conducting the other voltage of said direct currents, means in said secondary clock to stop its time-disclosing movement, means controlled by one of said direct currents adapted to speed up the movement of said secondary clock, and means controlled by the other of said direct currents for releasing said stop means including an electromagnetic coil in series with said field winding of each of said secondary clock motors, and means in said master clock for controlling

said direct current controlled means at said predetermined intervals.

2. A system according to claim 1 wherein said two direct current sources include a transformer connected to said alternating current source, a rectifier connected to said transformer and separate taps from said transformer to said rectifier.

3. A system according to claim 1 wherein said stop means includes a projection on a rotating means, a slidable lever and a projection engaging arm mounted on said lever for moving said lever in one direction.

4. A system according to claim 3 wherein said stop release means also includes a plunger controlled by said electromagnetic coil, and a lever engaging means mounted on said plunger for disengaging said arm from said projection by movement of said lever in a direction at right angles to the movement imparted to said lever by said projection.

5. A system according to claim 4 including a spring connected to said lever for restoring said lever whereby said arm is again in a projection engaging position after the operation of said stop release means.

6. A system according to claim 1 including manual means for speeding-up both said secondary and said master clocks simultaneously.

7. A system according to claim 6 including interlocking means to prevent said speeding-up by said manual means during said predetermined intervals.

8. In a system for synchronizing secondary electric clocks with a master electric clock, said secondary clocks each having a time-disclosing movement and being operated by a synchronous electric motor, the improvement comprising: means in each secondary clock for setting said secondary clock under the control of the master clock at predetermined intervals, a pair of current supply conductors connecting the motor of each secondary clock in parallel, each secondary clock motor having a field winding, said setting means comprising a clutch adapted for speeding up the movement of each said secondary clock, a first electromagnetic coil in each secondary clock for operating said clutch, a stop device for stopping the movement of the hands of each secondary clock, a second electromagnetic coil in each said secondary clock for releasing said stop device, control means in said master clock for consecutively operating said first and said second electromagnetic coils, a third conductor connected to each of said first electromagnetic coils in each of said secondary clocks, each of said second electromagnetic coils being connected in series with its associated field winding, one of said pair of conductors being connected to both of said coils in each secondary clock, whereby the motors of said secondary clocks and their coils are energized separately over only three conductors.

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